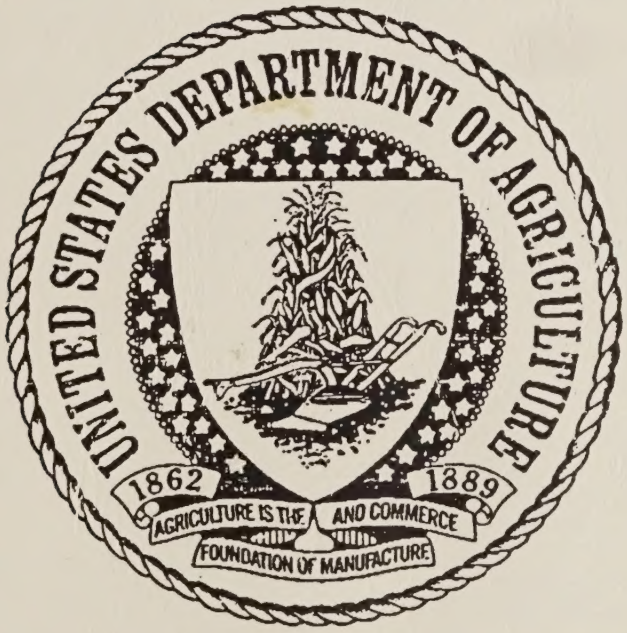
ARS-APHIS Joint Fruit Fly Research
Coordination Teams (RCT's)
Workshop

November 8-9, 1994
Building 005, Room 21-B
Beltsville, Maryland

Workshop & Team Reports



United States Department of Agriculture

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EXECUTIVE SUMMARY

The joint ARS-APHIS Fruit Fly Working Group in 1994 proposed to establish several Fruit Fly Research Coordination Teams (RCT's) in order to promote better communication and collaboration, and to ensure implementation of newly developed technologies within four areas of research that are considered high priority. These four areas are: I. Diet, Nutrition and Equipment; II. Sterile Fly Competitiveness and Strain Development, Irradiation and Commodity Treatment; III. Biocontrol Alternatives; and IV. Attractants, Trap Devices, and Chemical Control. Representatives from both ARS and APHIS were appointed as members to each RCT, with one member designated as a Team Leader.

Team Leaders were assigned the following responsibilities: a) Solicit full participation of all members; b) Set up regularly scheduled conference calls of the team members; c) Set up special meetings as needed; d) Serve as communication "hubs" and facilitate consensus among the participants; and e) Present progress reports to the ARS-APHIS Fruit Fly Working Group. Additionally each of the Research Coordination Team (RCT) members were assigned the following responsibilities: a) Fully report progress during conference calls and meetings; b) Communicate all intentions related to the research and logistical aspects of the program to the team leader and other team members; c) Seek concurrence by the team for activities in terms of mission contribution; and d) Participate fully in reports of key progress to the ARS-APHIS Fruit Fly Working Group on a periodic basis. Robert M. Faust, ARS and Pat Gomes, APHIS currently serve as overall coordinators and as the informational conduit between the ARS-APHIS Fruit Fly Working Group and the RCT's.

In order to initiate this activity, a mini-workshop consisting of four halfday sessions was held on November 8-9, 1994, in Beltsville, Maryland. The four halfday sessions had the following objectives -- 1) Formalize each team, define its scope, and select a team leader; 2) Validate and/or identify specific research needs for each area; 3) Assess current activities; 4) Recommend how best to ensure that each area meets the needs of the interagency fruit fly programs; and 5) Identify specific areas of focus for communication and collaboration, as well as select a process for communication. This report contains the recommendations resulting from the four halfday RCT sessions.

Robert M. Faust, ARS-NPS
ARS National Program Leader

Pat Gomes, APHIS-IS
Assistant Director
Science & Technology

RCT Goals

- Promote better and timely interagency communication and collaboration (ARS/APHIS-IS-PPQ-NBCI-BBEP).
- Ensure timely implementation of newly developed technologies.

RCT Team Leader Responsibilities

- Solicit full participation of all members.
- Set up regularly scheduled conference calls of the team members.
- Set up special meetings as needed.
- Serve as communication "hubs" and facilitate consensus among the participants.
- Present progress reports to the ARS-APHIS Fruit Fly Working Group on a periodic basis.

RCT Team Member Responsibilities

- Fully report progress during conference calls and meetings.
- Communicate all intentions related to the research and logistical aspects of the program to the team leader and other team members.
- Seek concurrence by the team for activities in terms of mission contribution.
- Participate fully in reports of key progress to the ARS-APHIS Fruit Fly Working Group on a periodic basis.

Research Coordination Team Reports

Team Title: Diet, Nutrition and Equipment (RCT-I)

Team Leader: Eric Jang, ARS, Hilo, Hawaii

Team Members:
ARS: Harvey Chan, Hilo, HI; Rick Edwards, Albany, CA; Daniel Moreno, Weslaco, TX.
APHIS: Tom Forrester, Mission, TX; Ray Penk, Mission, TX; Pedro Rendon, Guatemala City; John Worley (Recorder), Mission, TX.

Synopsis of Issues:

Team members were in general agreement that the overall goal of the team was to further optimize fruit fly mass-rearing technology and improve the quality of mass-reared flies. Issues discussed included diet formulation and preparation, automation, sanitation requirements, basic nutritional requirements, contract specifications and testing, and engineering and equipment needs related to mass-rearing.

Existing diet formulations for fruit flies are relatively inexpensive but formulations need to be optimized for each species and the optimal nutritional components identified. Physiochemical, environmental and microbial factors were identified as important.

Past research on diet recycling suggests that it may not be cost effective, however, waste disposal of spent medium is becoming increasingly expensive for mass-rearing facilities. The nutritive value of the spent medium is high and may be useful as animal feed, fertilizers, and other similar products. Possible usages for spent media should be further identified with any government liability of the resulting product for use by the agroindustry clearly established.

Information on the relative quality of mass-reared flies has been an intuitive process. There is a need to identify the basic nutritional requirements of fruit flies and determine if current diet formulations meet these requirements. There is also a need to determine if the relative quality of adult flies could be improved through manipulation of the diet.

Automation of mass-rearing procedures will depend on individual facility production requirements and labor expenses. A cost benefit analysis study should be implemented at each location involved with the development of mass-rearing technology. Equipment maintenance can be a significant cost factor, particularly in remote locations.

Contract specifications and standards are needed, but are only more easily defined in situations where the diet has been standardized. Location-specific diet formulations and lack of adequate information on basic nutritional requirements make it difficult to set specifications and standards.

Sterilization of adult flies using irradiation (see RCT-II) needs to be factored into any analysis of overall fly "quality". Engineering concerns

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involved with dispensing of sterile flies and closed-mixing systems for fly lures were highlighted as important considerations.

An open and timely exchange of information on available rearing systems was emphasized. The RCT members agreed that an illustrated manual for fruit fly rearing should be compiled and distributed. Information in the manual should include descriptive information of the rearing process, of the cost and source of materials, and of the engineering/automation systems. Such a document may be useful in future facility designs and planning.

Areas of Focus for Communication and Collaboration:
The following were identified as possible focus areas for team collaboration.

Diet and nutrition:

A. Studies that determine larval nutritive requirements and optimize physiochemical conditions.
B. Studies that identify microbial contaminants and remedial inhibitors of the diet.
C. Studies to develop uses for spent diet.
D. Studies to develop improved diets for the Malaysian fruit fly (*Bactrocera latifrons*) and the West Indian fruit fly (*Anastrepha obliqua*).
E. Studies to assess effects of diet on adult fly "quality".

Engineering and equipment:

A. Studies that assess current rearing procedures for possible automation.
B. Investigations on alternative methods to sterilize adult flies.
C. Studies to develop improved methods for holding and release of sterile flies and parasites.
D. Activities aimed at compiling an illustrated manual of fruit fly rearing methods for distribution.

Communication Process:
RCT-I team members are planning to communicate through E-Mail, quarterly conference calls and annual RCT group meetings. The first conference call is tentatively scheduled for the last week in February, 1995. The RCT agrees that site visits to existing mass-rearing facilities would further improve communication and facilitate advances in fruit fly mass-rearing.

Team Title: Sterile Fly Competitiveness and Strain Development, Irradiation, and Commodity Treatment (RCT-II)

Team Leader: Robert L. Mangan, ARS, Weslaco, Texas

Team Members:
ARS: Don McInnis, Honolulu, HI; Jennifer Sharp, Miami, FL; Vicky Yokoyama (Recorder), Fresno, CA; Daniel Moreno, Weslaco, TX; Jack Armstrong, Hilo, HI;
APHIS: Ed Gersabeck, Riverdale, MD; Pedro Rendon, Guatemala City, GT; Bob Spaide, Riverdale, MD; Robin Huettel, Riverdale, MD; Scott Wood, Riverdale, MD; David Lance, Waimanalo, HI; John Worley, Mission, TX.

Synopsis of Issues:

Research Coordination Team II will focus on issues and needs related to sterile fly competitiveness and strain development, irradiation, and commodity treatment. The team recognized that the issues related to sterile fly competitiveness (including the effects of irradiation on sterilized flies) and those related to commodity treatment (including irradiation for disinfestation) have little overlap except in Dr. Mangan's laboratory in Weslaco, Texas. Responsibility for sterile fly issues was designated to sub-team leaders David Lance (APHIS, Waimanalo), Donald McInnis (ARS, Honolulu covering Medfly issues and Daniel Moreno (ARS, Weslaco) covering *Anastrepha* (mainly, Mexfly) issues. Laboratories with heavy emphasis on commodity treatment issues (ARS, Weslaco; ARS Fresno; ARS, Miami) will focus exclusively on the various commodity treatment issues.

A. **Commodity Treatment Issues.** Quarantine issues including commodity treatment was considered a part of the 'Exclusion' section of the USDA-ARS Fruit Fly Research Action Plan (1992) and its supplement (1993). It was recognized by members of the team that laboratories performing research on commodity treatment are tightly associated with research concerned with other insect taxa, especially Lepidoptera (Fresno) and Coleoptera (Miami). The ARS, Weslaco and ARS, Hilo facilities are still mainly concerned with treatments for tropical Tephritidae. All four of these laboratories carry out research programs on host status, fly-free zones/periods, and systems approaches and strategies in lieu of treatment in order to achieve quarantine security against fruit flies. It was also recognized that the overwhelming majority of past research on quarantine issues has been performed by ARS laboratories and this situation is likely to continue into the future, especially research addressing the biology of fruit flies.

The major issues affecting quarantine-related research include methyl bromide replacement, loss (withdrawal) of pesticides, and changes in trade rules. Methyl bromide loss will probably have less effect on tropical fruit trade because many tropical fruits cannot tolerate methyl bromide and alternative

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strategies (fly free zones, heat/cold treatments) are already available or proven effective for fruits such as citrus that are currently fumigated. Withdrawal of pesticides may affect the maintenance of fly-free zones. Changes in trade rules, e.g. lowering of tariffs, have elevated the importance of quarantine research because quarantines are now the major barriers to export and import of many fresh commodities. The general priority recognized for these issues is that exports (from the U.S.) will have priority for commodity treatment and that research on potential or actual imports will be mainly associated with excluding foreign pests. The most important Tephritidae identified for addressing by the RCT were the Medfly, Mexfly, Melon fly, Oriental, and Caribbean fruit flies. The large numbers of hosts and past history of accidental introductions were the main criteria for setting these priorities.

There was some discussion of possible 'generic' treatments by irradiation for a range of fruit fly pests and commodities. In this discussion RCT members noted that the goal of probit 9 level mortality was not possible due to product damage in many commodities; treatments to prevent emergence or reproduction of adults should be the major criteria. Research, including confirmatory tests of dosages that prevent emergence, mobility, or reproduction of adults flies, has not been undertaken for the high priority fruit fly species and needs to be initiated as resources can be made available.

Other specific issues identified as associated with commodity treatment included irradiation dosage calibration. Systems are also needed to determine whether commodities arriving at ports of entry have been treated.

Improved insect detection methods are needed to implement systems involving maximum pest limits or when treatment intensity is determined as a result of rate of infestation. Advances have occurred with regard to acoustical devices and associated computer systems that may warrant attention. Non-destructive detection methods are preferred.

Tolerance of commodity to any treatment regime is an important first step. More work needs to be placed on this area rather than repeating insect mortality studies for many insect-treatment combinations. Pre-conditioning, seasonal/varietal variations, and conditions occurring from harvest to treatment time can reduce quality of treated commodities.

B. **Sterile Fly Issues.** The major issues and needs related to competitiveness for both Medfly and Mexfly were strain aging, loss of competitiveness due to adaptation to mass rearing environments, methods for determining fly quality that are relevant to actual fly performance in the field, radiation dosage and the need for standardization of calibration of different equipment, and the efficiency and effectiveness of *tsl* (temperature sensitive lethal) male-only strain being tested in Guatemala. Of particular interest were current programs to develop behavioral performance profiles for Medfly that may be used to design more relevant quality control criteria. The problems associated with determining causes (genetic, rearing conditions, diet quality,

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etc.) of fly quality deterioration are not new and continue to be addressed in both Mexfly and Medfly programs. For the Mexfly it was noted that a comparison of wild and 40+ year colony strains failed to reveal significant differences in mating successes but that sterilization caused a high loss of male competitiveness. Issues related to residual fertility in males (especially with genetic sexing strains) when tradeoffs with male fitness are favorable were identified as important.

The observation of increased resistance in the target population to sterile insect treatments in a Kauai field test for Medflies was noted. If this change in mating pattern is shown to be a genetically-controlled factor as a result of the application of the sterile insect technique, there could be significant ramifications for all SIT programs.

Newer designs and approaches to fruit fly irradiation technology, including methods to achieve more even distributions of dosages from 'hard' (gamma radiation) were highlighted. It was noted that the cost of designing and building irradiators is high, but given the multimillion dollar costs of the eradication program, as well as the value of the commodities protected by these programs, another look at optimal irradiator design may be worthwhile. The use of linear accelerator radiation sources was also noted. APHIS representatives from Florida discussed operational problems with the unit in Gainesville, but were generally optimistic that the concept is usable. Other 'soft' radiation techniques such as x-rays were suggested as possibilities that may allow for more precise control of dosages over the pupal container.

Areas of Focus for Communication and Collaboration:

Commodity treatment:

A. New or improved disinfestation methodology for replacement of methyl bromide fumigation.

B. Development of alternative strategies (pest-free zones, systems approaches) that alleviate the need for disinfestation treatments.

C. Projects that enhance the access of U.S. products to foreign markets under new freer trade conditions.

D. Development of 'generic' standards for developing and applying quarantine treatments.

E. Improved methods for regulation and standards for measuring radiation dosages for quarantine treatments.

F. Improved insect detection methods to implement pest-free zones and systems approaches to quarantine security.

Fly competitiveness and strain development:

A. Development of improved methods of measuring strain quality and the effects of mass-rearing adaptation.

B. Determination of standards for measuring and comparing radiation dosages for sterilizing flies.

C. Testing field performance of the male only, genetic sexing strain(s) of Medfly.
D. Determination of the relationship between radiation dosage and male fitness and any tradeoff in male performance improvement by allowing increased residual male fertility.
E. Investigations on the mechanism and possible consequences of the increase in resistance to sterile males observed in certain Hawaiian Medfly populations.

Both commodity treatment and sterile fly technology:
A. Examination of newer technologies involving 'soft' radiation sources such as linear accelerators or x-rays for sterilizing or killing fruit flies.

Communication Process: Periodic conference calls, E-mail, annual RCT group meetings, and informal visits. The first formal communication is tentatively scheduled for the last week in May, 1995.

Team Title: Biological Control Alternatives (RCT-III)

Team Leader: Mary Purcell, ARS, Hilo, Hawaii

Team Members:
ARS: John Sivinski, Gainesville, FL; Daniel Moreno, Weslaco, TX; James Lindegren, Fresno, CA; Nic Liquido, Hilo, HI.
APHIS: Allen Green, Riverdale, MD; Tim Holler (Recorder), Gainesville, FL; Dale Meyerdirk, Riverdale, MD; A. J. Martinez, Mission, TX; Pedro Rendon, Guatemala City, GT.

Synopsis of Issues:

A. **Foreign exploration.** Effective parasites for several fruit fly species are lacking in Hawaii, Florida, and Texas (Hawaii: Medfly, melon fly, Malaysian fruit fly; Florida: Caribbean Fruit Fly, Medfly; Texas: Mexfly). None of the parasites currently available are host specific (they will attack non-target fruit flies as well).

B. **Mass rearing.** Some species are difficult to mass rear (e.g., emergence rates are low, or fluctuate drastically for unknown reasons). More work is needed to increase production rates. Advances in rearing *Doryctobracon aerolatus, Diachasmimorpha longicaudata* and *Biosteres arisanus* are being made. Standard operating procedures for species that are in culture should be made available. A better understanding is needed of nutritional/micro-environmental requirements for parasitoids and minimizing genetic bottlenecks.

C. **Field Evaluation Criteria.** APHIS has emphasized the urgency for large-scale testing of parasite augmentation, with or without Sterile Insect Technology (SIT). Environmentally-safe alternatives are being seriously considered for regional eradication programs (e.g., Guatemala/Mexico). Questions remain regarding the limitations of parasitoids for control on crops, especially those with very low economic injury levels and/or zero tolerance, and satisfy quarantine concerns for export. Increased research and methods development coordination between ARS and APHIS scientists is needed (i.e. number and size of experimental plots, which parasites to use, release methods, etc.). Aerial release systems have never been tested with adult parasites and need to be developed.

D. **Microbial Control, Including Nematodes.** A new strain of nematode, Rio Bravo, has been tested on several lepidopteran pests, and may show promise for fruit fly control based on higher field survival than previously tested strains. This strain could be tested on fruit flies and non-target species. Field trials with *Bacillus thuringiensis* strains that have been demonstrated to be lethal in laboratory tests are needed. Only preliminary field studies have been completed.

Areas of Focus for Communication and Collaboration:

A. The development of an inter-agency plan for international exploration of new parasitoids. Improvement of existing linkages with international laboratories and staff (i.e. ARS biocontrol laboratory in Montpelier, France, APHIS *IS* overseas staff). Suggested list of fruit flies for parasitoid development: Medfly, Mexfly, caribfly, melon fly, and Malaysian fruit fly. Areas of search: Africa (including Madagascar, Reunion), Mexico, South America, and Southeast Asia. Increased linkages between APHIS, ARS and other foreign cooperators should be established.

B. Activities to build/improve/expand research facilities for quarantine and biological testing of exotic natural enemies before release (i.e. Guatemala, Hawaii, Texas).

C. Activities to revise the APHIS Guatemala fruit fly methods development and control plan. Identify collaborators and organize specific meetings for planning the strategy. Activities included with the initiation testing of aerial release systems for adult parasitoids.

D. Mass rearing research. The following species of parasites are currently being studied and will be a major focus for collaboration and communication: *B. arisanus, P. fletcheri, D. longicaudata, D. tryoni, Tetrastichus giffardianus and D. aerolatus.*

E. Activities involved with the development and publication of standard operating procedures for mass-rearing parasitoids.

F. Identifying location(s) for field testing the 'Rio Bravo' nematode strain for fruit flies.

G. Costs associated with mass-rearing and release of parasitoids must be determined to assess operational feasibility of their use for fruit fly control.

Communication Process:

Quarterly conference calls and annual RCT group meetings; periodic visits to Fresno, Gainesville, Weslaco, Hilo, and Guatemala laboratories to initiate collaborative work; meet with APHIS in Riverdale at least once per year.

Team Title: Attractants, Trap Devices and Chemical Control (RCT-IV)

Team Leader: Danny Gates, Mission, Texas

Team Members:
ARS: Nicanor Liquido (Recorder), Hilo, HI; Roy Cunningham, Hilo, HI; Barbara Leonhardt, Beltsville, MD; Al DeMilo, Beltsville, MD; Daniel Moreno, Weslaco, TX; Bob Heath, Gainesville, FL.
APHIS: Mark Knez, Riverdale, MD; David Lance, Waimanalo, HI; Pedro Rendon, Guatemala City, GT.

Synopsis of Issues:

A. **Attractants.** A combined male and female annihilation methods should be explored. The species-range-of-attraction of unknown lures and attractants to a suite of fruit fly species needs to be investigated. The effectiveness of the current bait spray applications needs to be enhanced.

B. **Trap Devices.** The optimum number and spacing of traps per unit area needs to be reevaluated. The trapping efficacy of the Jackson, yellow panel, C&C, and other types of traps needs to be quantified. The optimum amount of lure and type of dispenser needs to be determined for each type of trap.

C. **Chemical Control.** Continue to investigate the use of light-activated dyes as substitutes for malathion in bait spray programs.

Areas of Focus for Communication and Collaboration:

A. **Attractants.** Investigations on the possibility of combining pheromone, food-based attractants, and visual cues for female trapping; studies to determine the cross attraction of latilure and methyl eugenol analogs to other *Bactrocera* species; studies to determine the attractiveness of bacteria-derived attractants to Mexican fruit fly, Medfly and other fruit fly species; studies to determine the possibility of using trimedlure to enhance effectiveness of bait sprays; investigations on the possibility of eradicating low level population of Medflies by mass-trapping both males and females; studies to improve the attractiveness of NuLure, or to identify a more attractive hydrolyzed protein bait source.

B. **Trap Devices.** Studies that are aimed at reevaluating the optimum number and spacing of traps per unit area to detect low levels of Medfly population; studies comparing the trapping efficacy of Jackson, yellow panel, C&C, and other types of traps in California, Florida, Hawaii, and Guatemala;

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studies to develop slow-release dispenses for each known lure that also contain a toxicant; studies to determine the optimum lure load for each type of dispenser and trap.

C. **Chemical Control.** Studies to determine the level of light activated dyes to fruit flies of economic importance; studies to determine the environmental factors that may affect the efficacy of light activated dyes under various environmental conditions; studies that develop the best bait-dye formulation (i.e. concentration of the dyes, protein and sugar sources) for ground and aerial applications and feeding stations.

Communication Process:
Quarterly conference calls; RCT group meetings once a year either in Hawaii, California, or Beltsville/Riverdale.

APPENDIX A

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APPENDIX B

Fruit Fly Research Coordination Teams (RCT/Potential Issues & Needs)

RCT-I: Diet, Nutrition & Equipment

Diets & Nutrition

A. Diet formulation & preparation.
B. Recycling & disposal.
    1. Elimination of waste products.
    2. Potential reuses.
C. General sanitation requirements.
D. Basic nutritional requirements.
E. Contract standards/specifications & testing procedures for bulk diet ingredients.

Engineering & Equipment

A. Irradiation equipment.
    1. Electron beam/linear accelerators.
    2. Microwaves.
    3. Radioisotope devices.
    4. Non-radioisotope devices.
B. Diet preparation/mixing/dispensing/disposal.
C. Mechanization of rearing processes.
D. SIT release/dispenser systems.
    1. Aerial.
    2. Ground release.
E. Guidance/tracking systems for aerial & ground applications (SIT & chemical).
F. Automated methods of scanning traps/specimen identification
G. Application equipment (closed systems for mixing & treatment).

RCT-II: Sterile Fly Competitiveness/Irradiation/Commodity Treatment

Sterile Fly Competitiveness & Strain Development/Irradiation/Commodity Treatment Regimes

A. Criteria for assessing competitiveness & evaluation of strains.
B. Measuring & monitoring fly quality and interpretation of results.
C. Irradiation dose.
D. Identification of key behavioral, physiological, and environmental factors or cues.

E. Enhancement of performance.
F. Temperature sensitive lethal strain development & testing.
G. Dosage as it relates to sterility & competitiveness.
H. Calibration methods & standards.
I. Methods of determining whether mature & immature stages have been irradiated.
J. New technologies for sterilizing insects for SIT & commodity treatment purposes.
    1. Mobile linear accelerators.
    2. Microwaves.
    3. Other non-radioisotope forms of sterilization.
K. Commodity treatment regimes.

RCT-III: Biocontrol alternatives

Biological Control.

A. Use of parasites and predators.
    1. Criteria for selection and use of biological control agents for operational program use.
    2. Field evaluation criteria & standards.
    3. Mass-rearing methodologies.
    4. Assessment of potential predators & parasites for control purposes, including nematodes.
B. Use of microbials -- fungi, bacteria, viruses.
    1. Production methods.
    2. Application methods
    3. Biosecurity requirements.
    4. Genetically-engineered approaches.

RCT-IV: Attractants, Trap Devices & Chemical Control

Attractants & Trap Devices.

A. Chemical aspects of formulation, synthesis, and production of attractants, e.g., contract standards/specifications & testing procedures.
B. Relative efficacy/calibration of attractants.
C. New trap designs.
D. Criteria for use as detection and/or survey.
E. Behavioral, physiological and environmental cues or factors.

Chemical Control

A. Bait spray enhancement.
B. Substitutes for malathion & diazinon.